T 46: Di-Higgs 1 (bb$\tau\tau$)

Time: Tuesday 16:00–18:00 Location: Geb. 30.41: HS 1

T 46.1 Tue 16:00 Geb. 30.41: HS 1

Application of Deep Sets Neural Networks for the $b\bar{b}\tau^-\tau^+$ Di-Higgs Analysis with the CMS Experiment — •Stella Felice Schaefer, Peter Schleper, Philip Daniel Keicher, and Bogdan Wiederspan — University of Hamburg, Hamburg, Germany

Machine Learning has found a wide range of applications in particle physics. In the context of the CMS $b\bar{b}\tau^-\tau^+$ Di-Higgs Analysis neural networks are tasked with the classification of signal and background processes in order to measure the Di-Higgs coupling constant κ_λ as well as the coupling of two Higgs bosons to two vector bosons κ_{2V}.

Common problems for the proper application of neural networks are the variable number of jets per event, requiring padding of empty jets for a fixed number of input features, as well as the input order of jets passed to the network. Deep Sets neural networks provide a solution to both aforementioned problems, as these networks don't require fixed input shapes and act permutation invariant on the input.

This study aims to thoroughly test Deep Sets neural networks in the context of the CMS $b\bar{b}\tau^-\tau^+$ Di-Higgs Analysis for the application of signal process classification as well as signal vs. background classification and compares the performance to standard feed-forward architectures.

T 46.2 Tue 16:15 Geb. 30.41: HS 1

Signal-Background Discrimination Using Machine-Learning for the Resonant HH $\to b\bar{b}\tau^-\tau^+$ Analysis of CMS. — •Johan Wulff[1,2] and Michele Gallinaro[1,2] — [1]LIP - Laboratory for Instrumentation and Experimental Particle Physics, Lisbon, Portugal — [2]Instituto Superior Técnico, Lisbon, Portugal

After the discovery of the Higgs boson by the CMS and ATLAS collaborations in 2012, various couplings to other particles of the Standard Model were successfully measured. The concrete shape of the Higgs potential, however still remains to be experimentally probed. The search for Higgs boson pair production plays a key role in uncovering the shape of the potential, as it can be expressed in terms of the self-coupling parameter, which in turn can be constrained through measuring the pair production rate. At the LHC, this process can either arise through gluon gluon fusion (ggF) or vector boson fusion (VBF). For both scenarios, the overall production cross section is small whilst dominating backgrounds render the search notoriously challenging.
For this reason, it is essential to discriminate signal from background events in an optimal manner. The use of advanced machine learning algorithms is imperative in tackling this classification problem. This contribution presents the development of such an algorithm aimed at separating signal and background for the search for Higgs boson pair production in the $b\bar{b}\tau^-\tau^+$ final state with the CMS detector.

T 46.3 Tue 16:30 Geb. 30.41: HS 1

A neural network based regression of the neutrinos in H$\to\tau\tau$ decays in the context of the CMS resonant HH$\to$bb$\tau\tau$ analysis — Philip Keicher, •Tobias Kramer, Marcel Rieger, and Peter Schleper — Universität Hamburg

The CMS resonant HH$\to$bb$\tau\tau$ analysis searches for the decays of heavy spin 0/2 resonances to a pair of Higgs bosons in the bb$\tau\tau$ final state. It uses the data collected from 2016-2018 (Run 2) at $\sqrt{s} = 13\,\text{TeV}$ corresponding to an integrated luminosity of 138 fb^{-1}. One important challenge is to reconstruct the kinematics of the two Higgs bosons. Especially in the H$\to\tau\tau$ decay a large fraction of the energy is lost, because the neutrinos resulting from the τ decays are not detected. This talk presents studies on how to regress the full HH system using deep neural networks and the effects of including an additional classification part as well as parameterized (in mass and spin of the resonance) approaches.

T 46.4 Tue 16:45 Geb. 30.41: HS 1

Streamlined optimization studies in the search for di-Higgs boson production — •Steffen Ludwig, Karsten Köneke, Christian Weiser, and Karl Jakobs — University of Freiburg, Institute of Physics, Freiburg im Breisgau, Germany

The Higgs boson has been studied at the Large Hadron Collider at CERN over the last decade with ever-increasing precision. However, one key quantity, the strength of the trilinear Higgs boson coupling, has still eluded direct precision measurements. A measurement of its coupling strength modifier κ_λ, defined as the ratio of the observed value by its Standard Model prediction, that differs from unity would be a sign of new physics.

I will discuss the prospects of the search for the non-resonant production of Higgs boson pairs in the HH $\to$ b$\bar{\text{b}}\tau^+\tau^-$ channel using 140 fb^{-1} of proton-proton collisions at a centre-of-mass energy of 13 TeV recorded by the ATLAS detector at CERN.

To study the impact of Graph Neural Networks on the analysis, I developed an automatization tool called grid-pipeline to conduct and orchestrate the original analysis pipeline and its derivatives. Due to its versatility, it enables the elementarization of complex computing workflows, even in mixed computing site scenarios. This allows for a highly improved analysis optimization workflow and minimized turn-around time.

T 46.5 Tue 17:00 Geb. 30.41: HS 1

Improving the sensitivity to the Higgs boson self-coupling in the $HH \to bb\tau\tau$ channel with the ATLAS experiment — •Katharina Häussler, Christian Weiser, Karsten Köneke, and Karl Jakobs — University of Freiburg, Germany

The Standard Model (SM) predicts interactions involving multiple Higgs bosons, which have yet to be observed experimentally. Higgs boson pair production provides the most sensitive test of such triple Higgs boson self-interactions and the $bb\tau\tau$ final state presents a good compromise between expected signal yield and background contamination, making it one of the three golden channels to explore this phenomenon.

This talk focuses on improvements that can be made in future analyses to increase the sensitivity to anomalous values of the Higgs boson self-coupling modifier κ_λ. Significant deviations from the SM prediction would provide a strong indication of physics beyond the Standard Model.

T 46.6 Tue 17:15 Geb. 30.41: HS 1

High Level Trigger Optimization Studies in the Atlas search for Higgs Boson Pair Production in the HH $\to b\bar{b}\tau^+_{\text{had}}\tau^-_{\text{had}}$ channel — •Athul Dev Sudhakar Ponnu, Stan Lai, and Andrés Melo — II. Physikalisches Institut, Georg-August-Universität Göttingen.

The Standard Model of particle physics predicts the existence of the trilinear Higgs self coupling vertex. This can be studied through the Higgs boson pair production process, which is yet to be observed. To increase the probability of observing this process, studies for the optimisation of the High Level Triggers for the search of the HH $\to b\bar{b}\tau^+_{\text{had}}\tau^-_{\text{had}}$ final states have been performed.

The specific goal is to improve signal acceptance and background rejection of the trigger chains relevant for the study of the HH$\to$ $b\bar{b}\tau^+_{had}\tau^-_{had}$ channel using a trigger emulation framework developed for this purpose. The trigger selection criteria for two different di-τ trigger and the $b+\tau$ trigger have been fine-tuned to increase signal selection efficiency while maintaining or, in some cases, decreasing background rates.

T 46.7 Tue 17:30 Geb. 30.41: HS 1

Separation of HH and HZ final states Using Spin Correlations — •Celine Stauch, Christoph Ames, Otmar Biebel, Youn Jun Cho, Stefanie Götz, Edis Hrustanbegovic, Lars Linden, and Lukas von Stumpfeldt — LMU Munich

At the LHC a prominent background process to the HH production is the production of a H and Z boson. The HH and HZ processes are kinematically very similar since both processes have similar cross sections and the H and Z boson are close in mass. However, the H boson is a scalar particle while the Z boson has a spin of 1. The spin of the Z boson transfers to the final state particles and ultimately impacts their direction.
To investigate the impact of the particle spin on the final states, two approaches based on the Ellis-Karliner angle are applied. Further, methods to improve the selection of the final state jets are investigated. The results of this analysis suggest that a modified Ellis-Karliner angle provides an observable which is usable to distinguish between HH and

HZ final states.

T 46.8 Tue 17:45 Geb. 30.41: HS 1

Methods for the simulation of the Z+jets process at CMS
— Alena Dodonova, Ming-Yan Lee, •Andrey Pozdnyakov, Uttiya Sarkar, Alexander Schmidt, and Valentyn Vaulin — III. Physikalisches Institut A, RWTH Aachen University

The Z+jets process is a major background for searches for the Higgs boson decay to charm or bottom quarks, in associated production with a Z boson (ZH). Its modeling and sufficient statistics of the simulated sample are important factors for a competitive physics analysis. Two methods of the event generation which allow to enhance the statistical power of the samples in a given phases space (called phase space biasing) are discussed in this presentation. The first method is to produce samples binned in a relevant variable at Matrix Element (ME). The other one is to bias the sample at high transverse momentum at ME level, effectively generating more events at higher momenta.

A comparison of the simulated samples produced with Madgraph (LO), amc@NLO and Powheg MiNNLO generators in the phase space relevant for the ZH analysis is also shown.